Arago (in 1811) and of Brewster, relative to sky polarization, and the experiments of Brücke and of Tyndall[2] first indicated the true explanation, and later the necessary theory was supplied by Lord Rayleigh.[3] The conclusions of the latter have been verified by King,[4] Cabannes[5] (who was the first to observe the scattering of light by dust-free air), Lord Rayleigh (then Prof. Strutt), who made a very comprehensive study of the relative scattering power of different gases and its dependence upon the density of the gas, together with an investigation of the state of polarization of the scattered light,[6] and R. W. Wood.[7]

On the subject of the light from the night sky and whether or not it can all be accounted for by starlight; as well as whether the total light from all theoretically existing stars can satisfactorily account for the observed illumination of the night sky, a voluminous literature exists.[8]—*E. W. W.*

[2] W. J. Humphreys, loc. cit. H. H. Kimball, Jour. Frank. Inst., April, 1911, p. 344.
[3] Phil. Mag., vol. 41, pp. 107, 274, 447, 1871; vol. 12, pp. 81, 1881; vol. 47, p. 375, 1899.
[4] L. V. King, On the Scattering and Absorption of light in gaseous media, with applications ot the intensity of sky radiation, Phil. Trans., A, 212, 375–433, 1913.
[5] J. Cabannes, Sur la diffusion de la lumière par l'air, Comptes Rendus, 160, 62–63, 1915.
[6] Proc. Roy. Soc., A, 94, 453; 95, 155, 1918.
[7] R. W. Wood, Light Scattering by Air and the Blue Colour of the Sky, Phil. Mag., 39, 423–433, 1920; see Monthly Weather Review, 48, 220, April, 1920; also Monthly Weather Review, 44, 246, 1916; 45, 484, 576, 1917; 46, 70, 1918; 47, 797, 1919. On the brightness and total light of the sky, etc., see the *Annals* of the Astrophysical Observatory, Smithsonian Institution; F. E. Fowle, Atmospheric Scattering of Light, Smiths. Misc. Coll., 69, No. 3, 1918; A. F. Moore and L. H. Abbot, Brightness of the Sky, Misc. Coll., 71, No. 4; M. Luckiesh, Aerial Photometry, Astrophys. Jour., 49, 108–130, 1919; Monthly Weather Review, 47, 540, 1919.
[8] See, e. g., E. E. Barnard, On the Dark Markings of the Sky, Astrophys. Jour., 49, 1–23, 1919; W. J. Humphreys, On "Earth-Light," or the brightness, exclusive of starlight, of the midnight sky, Astrophys. Jour., 35, 273–278, 1912; E. E. Barnard, Self-Luminous Night Haze, Proc. Amer. Phil. Soc., 50, 246–253, 1911; 58, 223–235, 1919; P. J. van Rhijn, On the Brightness of the sky at night and the total amount of starlight, Astrophys. Jour., 50, No. 5, 1919; W. D. MacMillan, Astrophys. Jour., 48, 35–49. 1918; V. M. Slipher, Astrophys. Jour., 49, 266–275, 1919.

RAINFALL AT MUSCATINE, IOWA.

By Wm. P. Molis.

The *Journal of the American Water Works Association*, for January, 1920, pages 127–131, contains an interesting and practical discussion of the use of rainfall data in the municipal water works. The data on rainfall at Muscatine covered a period from 1846 to 1918. As the author points out, "the rainfall is the source of the water supplies of our communities, and long-time records of it are invaluable in estimating the quantity of water obtainable from a surface supply and in investigations of the quantity which exists as ground water. Such data are also valuable in studies of the relation between rainfall and floods. Few who have not experienced flood difficulties realize the danger which may arise if their pumping stations and machinery are situated on low lands exposed to overflow. A rain of one week or a cloudburst will suddenly swell the streams to such a height as to make quick work by the water department necessary in order to save the plant from being put out of commission."

It was found that the average annual rain and snowfall was about 37 inches. The minimum for the period studied was 23.04 inches in 1910, and the maximum was 74.50 inches in 1851. Another interesting point is that when the average precipitation for two thirty-year periods, 1846–1875 and 1876–1915 are compared it is found that it is 2.46 inches less for the second period than the first. Unusually severe rains (at Muscatine, those over 1.5 inches in 24 hours are so regarded) are studied with a view to determining the probability of such occurrences; it is believed that if a 2-inch fall of rain does not occur at some time during the first six months of the year, it is almost certain to occur during July, August, or September. It is dangerous, of course, to place too much confidence in such frequency tables, but, when this fact is remembered, such data may be of grrat practical value to the superintendent of water works in planning to meet emergencies.—*C. L. M.*

CERTAIN ENVIRONMENTAL FACTORS INFLUENCING THE FRUITING OF COTTON.

By E. C. Ewing.

[Technical Bull. No. 8, Miss. Agr. Expt. Station, 1918.]

The relation of weather and soil conditions, and of the varietal, or hereditary, factors, to the rate of fruiting and shedding are treated in considerable detail, but this review is restricted to the meteorological aspect of the problem.

A daily census of flower production, started in 1911, showed a pronounced variation in the number of flowers opening from day to day. Weather influence on this variable rate was suspected; but owing to limited meteorological data, the maximum and minimum temperatures, precipitation, and the charcter of the day as to the degree of cloudiness, no definite relation between any of these weather elements and the rate of blossoming was apparent. In 1913 additional meteorological instruments were installed, including a thermograph, hygrograph, porous cup atmometer, and a photographic sunshine recorder. In addition, soil moisture observations were made each day, first to a depth of 12, and later to 18 inches. Observations were made on this basis during that and the succeeding year, except for sunshine in 1914 when a defect in the sunshine recorder prevented observations by that instrument.

The tabulation and study of the data obtained from these observations, however, did not show any marked or dependable relation between the additional data secured and the rate of blossoming. In the case of temperature, the curve indicating the daily minimum values appeared to vary rather frequently in the same direction as the flowering curve. As a result of the studies during the four-year period from 1911 to 1914, it may be stated, but only in a very general way, that temperatures below 65° F. may be expected to decrease the number of flowers opening about two days later.

There was also some indication of agreement between the percentage of soil moisture and the flowering data, but this was less suggestive than in the case of minimum temperature. Increased soil moisture seemed to inhibit flowering somewhat, irrespective of the trend of the minimum temperature curve, as in some cases the rate of flowering was retarded after rain and increased soil moisture when the minimum temperature remained high.

The other weather elements showed little or no relation to the rate of flowering, but unfortunately, from the experimental viewpoint, no abnormalities of consequence in the weather elements prevailed; otherwise more definite results probably would have appeared. During protracted periods of cloudy and rainy weather, rank stock growth in cotton at the expense of fruit is not uncommonly observed, for under such conditions growth occurs mostly, not so much by multiplication of nodes as by the lengthening of the inner nodes.

Normal shedding, or abscission, of a variable number of immature fruits of the cotton plant is the general experience in America. It is the opinion of cotton growers that either too little or too much moisture will cause cotton shedding. From some studies made in Egypt, it has been shown that shedding becomes abundant there toward the end of the interval between irrigations and decreases directly after waterings, but finally becomes excessive again when the water level is raised and the lower soil becomes saturated by the infiltration of flood water from the rising Nile.

In the Mississippi studies there appears to be no basis, on the whole, for assuming that temperature has any appreciable effect on shedding; but it seems from the data collected that the moisture factor is important, the data showing that an insufficient supply of moisture tends to excessive shedding. There was no opportunity, however, for observing the effect of protracted periods of wet weather, so this aspect remains to be studied. The outstanding feature of the moisture and shedding curves is the apparent relation between that for evaporation and that for shedding, in which a high rate of evaporation and decreased soil moisture frequently correspond to a rise in the shedding curve, if an arbitrarily established period of four or five days is allowed to intervene between apparent cause and effect, or for the action of the stimulus to shedding.

Reviewer's note.—In the study of the relation of weather to such ecological phenomena as the fruiting of cotton, it is unfortunate that sufficient observational data are not available for the establishment of at least an approximate normal curve, to permit of a mathematical correlation of departures from the normal weather factors, and departures from the normal frequency curve. The first flowers appear in a field of cotton from 7 to 10 weeks after planting; and production gradually, but irregularly, increases to a maximum, after which it decreases in like manner to the close of the flowering period. Owing to this fact the advantages of a normal frequency curve are obvious, as by its use the normal increase or decrease in the curve for a particular time period may be eliminated and only the abnormalities considered.—*J. B. Kincer.*

THE BIOCLIMATIC LAW.[1]

By Dr. ANDREW D. HOPKINS, Bureau of Entomology.

[Abstract.]

The normal northward and upward advance of the leafing out of trees, the appearance of insects, etc., in spring, and the southward retreat of phenological events, in autumn, have been the subject of observation for more than a century in the United States. Dr. Hopkins has been particularly drawn to the study of phenology by the value of knowing the time of emergence of certain forest insects and of the hessian fly. His studies which led him to examine planting and harvest dates as well as other phenological dates has placed on a firm foundation the *bioclimatic law.*[2] Dr. Hopkins's own statement follows:

Variations in the date of a periodical event from a given norm or constant are a measure, in terms of time, of the intensity of the controlling influences and forces as related (*a*) to geographical position, (*b*) to the season, (*c*) to the inherent tendency of species under the same external influences to vary towards early and late individual responses, and (*d*) to early and late responses of individuals of the same variety under varying local influences. The variation from a constant in the date of an event also measures the intensity of the controlling influences in terms of distance as related to feet of altitude or equivalents in degrees of latitude or longitude.

Studies in the application of these principles show quite conclusively that the responses to the controlling influences and forces are in accordance with natural law, in that (*a*) the time of occurrence of a given periodical event in the seasonal activity, or (*b*) the latitude limits of distribution of an organism, or (*c*) its altitude limits, are determined primarily by geographical position. Therefore, *other things being equal*, the variation between two or more geographical positions bears the same proportion to the distance between them, that 4 days of time bears to 1 degree of latitude, 400 feet of altitude, or 5 degrees of longitude [average only for the whole width of the continent]. * * *

As measured in time the variation from the constants is found to range from one to forty, with a maximum of fifty days at certain points along the Pacific Coast. As measured in altitude the variations are from 100 to 3,000 , with a maximum of 5,000 feet. In these departures the earlier dates and higher altitudes are the result of accelerating influences, and later dates and lower altitudes are due to retarding influences.

In order to gather further facts and evidence on the variations from the constant and also the rate of advance of the spring season, as revealed by periodical phenomena, observations were begun at Brownsville in southeastern Texas and at Palm Beach and Miami, Fla., in February of the present year (1919). These were continued along routes from Brownsville in a general northeastward direction to the northern borders of the States of New York, Vermont, and Maine, and to above the timberline on Mount Washington, from Miami north along the Atlantic coast to Washington and from Palm Beach across the Florida Peninsula to Fort Wayne, then north to Lake City and west to Pensacola, and return to Washington by the way of Birmingham, Ala., Atlanta, Ga., and Charlotte, N. C. These routes involved a travel, principally by rail, by Messrs. Griffith, Craighead, Snyder, and the writer, of over 20,000 miles and the recording of over 20,000 observations. The data accumulated by these investigations has served not only to verify the facts and evidence furnished by the wheat harvest and altitude limit data but has contributed information toward the solving of many other problems of scientific and economic interest, relating to the application of the law in research and practice. * * *

[1] Jour. Wash. Acad. Sci., Jan. 19, 1920, 10: 34–40.
[2] See MONTHLY WEATHER REVIEW, Suppl. 9, 1918, and *Scientific Monthly* June, 1919, 8: 496–513.

BAROMETRIC GRADIENT AND EARTHQUAKE FREQUENCY.

By T. TERADA and S. MASUZAWA.

[Abstracted from Proc. of Physico-Math. Soc. of Japan, 3 ser., vol. 1, pp. 343–347, 1919.]

For each of a number of areas surrounding a given epicentral zone, the mean barometric gradient (amount and direction) for each of n successive years is calculated; the mean of the n means is taken, and the departure of each from this general mean found; the product-sum of these departures and the number of quakes originating in the epicentral zone during the corresponding year, divided by the total number of quakes, gives a vector which may be considered in some measure as the most effective deviation of the barometric gradient of that area in causing earthquakes in the particular zone. The mapping of the vectors for each of the areas surrounding the zone throws some light on the general seismic mechanism.

For two epicentral zones of Japan, the data for 1902–1915 show that most of the deviation vectors (pointing toward the high pressure) are nearly perpendicular to the axis of the island, those to the west of a line from Sado to Tokyo being directed more or less toward the Pacific side, and those to the east pointing generally toward the Japan Sea side; the type of surface loading suggested, if applied simultaneously, would be favorable to effect or produce fracture of a fissure located along, or parallel to, this line.—*E. W. W.*

EARTHQUAKE FREQUENCY AND RAINFALL.

In the Tokyo *Asahi* for January 29, 1913, Prof. Omori directed attention to a remarkable coincidence between the frequency of earthquakes as recorded at Tokyo by the seismometer and the total amount of rain and snowfall in northwestern Japan; but was unable to assign a reason for the apparent relationship. According to *Nature* (vol. 91, p. 65, 1913):

The relationship is borne out by statistics covering the whole of the Meiji era—45 years from 1867. The number of earthquakes recorded annually at Tokyo between 1876 and 1909 is found to be practically in